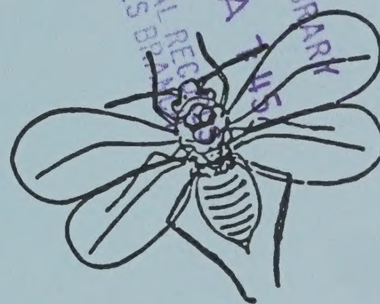
SOUTHERN INSECT MANAGEMENT RESEARCH UNIT USDA/ARS

Stoneville, Mississippi



Annual Report on Progress (CY 1997) and Plans (CY 1998)

CONTENTS

I. INTRODUCTION:

THIS REPORT SUMMARIZES progress made on various research objectives in 1997 and presents plans for 1998.

Many of the results are preliminary and others are being released through established channels. Therefore, this report is not intended for publication and should not be referred to in literature citations.

The intent of this report is to give the reader an overview of Southern Insect Management Research Unit (SIMRU) activities. These activities (progress and plans) address the research unit mission (listed on page 2).

SIMRU activities are centered around seven research thrusts, which reflect present CRIS work units. These are:

1. Biological and genetic control and area-wide management of crop insect pests, emphasizing *Heliothis/Helicoverpa*;

2. Population ecology of insect pests for integrated control/ management systems;

3. Biology, ecology, behavior, and biological control of plant bugs, cotton aphids, and silverleaf whitefly;

4. Integrated control of pecan pests;

5. Strategies for managing crop insects, emphasizing the cotton agroecosystem, pesticide effectiveness, and Bt resistance monitoring and management;

6. Host plant resistance in soybean pests; and

7. Rearing of seven insect species in support of research around the world.

This report is divided into four sections:

1. Report on research progress in CY 1997;

2. List of publications including those in press and accepted for publication;

3. Other indicators of progress such as presentations and papers in manuscript; and

4. Plans for CY 1998.

Items in each section are arranged alphabetically by lead scientist; the name of cooperating and/or collaborating researchers are provided. If the reader has questions pertaining to the item, he/she should contact the individual scientist or research leader.

II. MISSION STATEMENT AND STAFF:

SOUTHERN INSECT MANAGEMENT RESEARCH UNIT
ARS/USDA, Mid South Area
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MISSION:

To develop new knowledge on the biology of field crop insects for development of new and improved control tactics and to establish fundamental principles for encouraging and using natural enemies more effectively. To develop and integrate insect suppression strategies into field crop and pecan systems that minimize the cost of plant protection, yet are ecologically acceptable. Specifically:

1. Elucidate the efficacy of indigenous predators and parasites, particularly those attacking the bollworm, *Helicoverpa zea*, and tobacco budworm, *Heliothis virescens*.

2. Research and develop methods for augmenting parasite populations in management of insect pests of field crops, particularly parasitoids for control of *Heliothis/Helicoverpa*.

3. Develop new knowledge on biology and behavior of *Heliothis/Helicoverpa* spp. and beet armyworm, including use of entomopathogenic viruses in management of the latter.

4. Conduct basic biological and ecological research on plant bugs, particularly the tarnished plant bug, *Lygus lineolaris*, cotton aphid, *Aphis gossypii*, and the silverleaf whitefly, *Bemesia argentifolii.*

5. Develop monitoring and predictive technology through quantitative population ecology for field crop insect pests, particularly bollworm/budworm, tarnished plant bug, and cotton aphid.

6. Assess the role of early season host plants in the buildup of *Heliothis/Helicoverpa*, beet armyworm, and tarnished plant bug populations and devise new and innovative tactics for suppressing these populations, including use of entomopathogenic viruses in area-wide management of these pests.

7. Develop chemical/biorational control tactics for use in integrated systems.

8. Develop chemical, biological, and other nonchemical methods for control of insect and mite pests of pecans. Evaluate selections and native pecans for yield and adaptability to the mid-south.

9. Monitor for Bt resistance and develop resistance management tactics.

10. Locate, develop, and evaluate soybean cultivars resistant to insects.

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III. SUMMARY OF RESEARCH PROGRESS FOR CALENDAR YEAR 1997:

A. *NARRATIVE:*

1. In-House

Production of insects for USDA--ARS research by the Stoneville Insect Rearing Unit required maintenance of seven insects species: *Heliothis virescens, Helicoverpa zea, Anticarsia gemmatalis, Pseudoplusia includens, Spodoptera exigua, Cardiochiles nigriceps,* and *Cotesia kazak.* Support of USDA--ARS scientists at Stoneville and laboratories in Weslaco, TX; Tifton, GA; Mississippi State, MS; College Station, TX; and Gainesville, FL, required production of 153,000 *H. virescens* pupae, 144,000 *H. zea* pupae, 166,720 *P. includens* pupae, 91,200 *A. gemmatalis* pupae, 91,800 *Spodoptera exigua* pupae, 40,590 *Cardiochiles nigriceps* cocoons, 75,874 *C. kazak* cocoons, 38,250,000 *H. virescens* eggs, 36,000,000 *H. zea* eggs, 14,064,000 *P. includens* eggs, 9,525,900 *A. gemmatalis* eggs, and 5,178,000 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 67,740 30 ml cups and 601 3.8 liter multicellular trays with artificial diet. Total diet mixed and dispensed in 1997 was 13,670 liters. Several short courses in insect rearing techniques were given to employees of Thermo Trilogy Laboratory, Columbia, MD, and K-I Chemical USDA, Inc., Leland, MS. Approximately 150 researchers located in 37 states, England, Canada, and Japan participated in the Cotton Foundation and United Soybean Board Insect Distribution Programs. **(R. L. Ford)**

A third and final year study of boll weevil emergence and movement in the mid-Delta of Mississippi showed again that (1) from a start of low to moderate levels in the spring, late season numbers were extremely high; and (2) considerable movement of overwintered and first generation weevils occurred after bloom as detected by pheromone traps, especially 1-3 miles from the closest cotton. Sex ratios are still being determined, but trends indicate approximately 55:45 female:male ratio in traps from March through June and August 10 to frost, with over 90% females from July 1 - August 10. **(D. D. Hardee, L. C. Adams)**

Boll weevil adults captured from March 1996 through January 1997 were analyzed for pollen to determine alternative foraging resources. For analyses, samples were divided by season: Spring = March, April, and May; Summer - June, July, August; Fall = September, October, and November; and Winter = December and January. Boll weevils captured at 821 site-dates were processed; of those only 23 occurred in winter. Over 5,000 boll weevil adults were processed; most of which were collected in Fall. Boll weevils in Spring had a higher percentage of pollen (96%) than other seasons, and weevils captured in Winter had the lowest percent pollen (61%). Overall, 301 pollen types, 81 families, 132 genera, and 28 species

III. SUMMARY OF [illegible] PROGRESS FOR CALENDAR YEAR 1997

[illegible]

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[illegible] and [illegible] Mississippi showed [illegible] to moderate levels [illegible] moths [illegible] common [illegible] most of [illegible] occurred [illegible] Generally [illegible] [illegible] rates [illegible] determined [illegible] approximately 55:45 female:male ratio [illegible] March through June and August [illegible] with [illegible] 90% males [illegible] 10. [illegible]

[illegible] March 1? through [illegible] 1997 [illegible] pollen to determine alternative [illegible] [illegible] samples were divided [illegible] Spring = March, April and M[illegible] [illegible] August; Fall [illegible] September, October and November; Winter [illegible] December [illegible] January. [illegible] weevils captured at 321 sites [illegible] of these only 23 occurred in Winter. Over 5,[illegible] boll weevils were [illegible]; most of which were collected in Fall. Boll weevils in Spring had a higher [illegible] than the other seasons [illegible] in Winter but the lowest [illegible] (Overall, 301 pollen [illegible] 32 genera and 28 species

[illegible] for USDA-ARS [illegible] Stoneville Insect Rearing Unit [illegible] of seven insect species, [illegible] virescens, Helicoverpa zea, [illegible] grandis, [illegible] Spodoptera exigua, [illegible] and [illegible] Support [illegible] scientists in Stoneville [illegible] Weslaco, TX, Tifton, [illegible] State, MS, College Station, TX [illegible] FL required production of [illegible] H. virescens pupae, 144,000 H. zea [illegible] 166,??? [illegible] pupae, 91,??? [illegible] pupae, 91,800 Spodoptera [illegible] 40,590 Cardiochiles nigriceps [illegible] 5,??4 C. [illegible] [illegible] H. virescens eggs, 36,000,000 eggs, 16,000,000 H. zea eggs [illegible] eggs and 5,1??,??? [illegible] [illegible] research support [illegible] Inc., and [illegible] cups and 601 3.8 liter [illegible] trays with artificial diet. [illegible] 1997 was 13,070 [illegible] courses in insect rearing [illegible] given to [illegible] Colombia [illegible]

were encountered in the site-date samples. Fall contained more pollen types (187) than other seasons. Both Summer and Fall samples contained pollen from the greatest number of plant families, with more genera (89) represented in Fall samples. Mean number of pollen grains in Fall (80) was double that of any other season. Spring contained the largest mean number of pollen types (7), but Summer had the most types per site-date. Fabaceae (bean family) pollen accounted for more pollen types in Spring and Summer. In Fall and Winter, more Asteraceae pollen types occurred. **(D. D. Hardee, Gretchen Jones, ARS, College Station, TX)**

Studies were initiated in 1997 in a portion of the boll weevil eradication zone near Collins, Mississippi, to determine the feasibility of substituting bait sticks (BWACT®-boll weevil attract and control tubes) for pinhead square and/or fall diapause sprays in support of boll weevil eradication. Results were inconclusive but plans are to repeat the test with minor modifications in 1998. **(D. D. Hardee, L. C. Adams)**

Preliminary *B.t.* resistance monitoring in cotton in populations of cotton bollworm (CBW) and tobacco budworm (TBW) was initiated in 1996 by subjecting 23 different populations of these insects collected in Arkansas, Mississippi, Oklahoma, and Texas to field doses of MVP II biological insecticide in spray chamber bioassays (the toxic protein in MVP II is the closest in toxicological properties of all *B.t.* insecticides to the Cry I A (c) protein expressed in transgenic cotton). These tests were expanded in 1997 by subjecting 67 colonies (24 tobacco budworm, 43 cotton bollworm) submitted by 27 cooperators from 9 states to MVP II overlays in diet. As in 1996, the data showed no dramatic shifts in development of resistance of these insects to *B.t.* insecticide proteins in diet (and by inference, to *B.t.* cotton). **(D. D. Hardee, L. C. Adams)**

Furadan at 0.25 lb AI/A and Provado at 0.047 lb AI/A provided significant reductions in cotton aphid numbers at 3, 6, and 9 days after treatment when aphids were sampled in the top and middle portions of the plant. Bidrin at 0.4 LB AI/A and a kaolin powder (25 lb/100 gal water) reduced aphid numbers when compared to an untreated check but not significantly. **(D. D. Hardee, L. C. Adams)**

Several proprietary compounds from Uniroyal Chemical Company and Helena Chemical Company were tested against cotton bollworm/tobacco budworm larvae and eggs, respectively; yield records were obtained where possible. No counts were taken for boll weevil, stink bugs, or aphids due to low numbers, but some data were recorded for tarnished plant bug. All data have been forwarded to both companies. **(D. D. Hardee, L. C. Adams)**

Moth trap records in 1997 compared to 1996 collected at the same trap sites showed that: (1) beet armyworm numbers were 85% as high; and (2) cotton bollworms and tobacco budworms were reduced almost 70%. Reduced bollworm numbers may in part be due to a 20% reduction in corn acres in 1997 compared to 1996. In 1996, tobacco budworms reduced over 60% compared to 1995, so numbers of these insects continue to decline, perhaps partially due to plantings of *B.t.* cotton. **(D. D. Hardee, L. C. Adams)**

Results from a second year test of two insecticide treatments (7 days apart) for cotton aphid on NuCotn 33B and Sure-Grow 125 at three different growth stages (pre-pinhead square, full-grown square, first bloom)

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[illegible] ... [illegible]

[illegible] ... [illegible] results [illegible]

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[illegible] ... [illegible]

[illegible] ... [illegible] ... L. C. Adams)

Moth [illegible] controls [illegible] 1990, collected [illegible] the [illegible] (1) beet armyworm [illegible] high; and (2) [illegible] bollworm [illegible] Reduced bollworm numbers [illegible] compared to 1990. [illegible] 1990, [illegible] bollworm reduced over [illegible] 1990, no numbers [illegible] decline, reduced partially [illegible] [illegible] (G. [illegible], L. C. Adams)

Results [illegible] a [illegible] [illegible] [illegible] ... 11B and [illegible] (pre-plant) ... [illegible]

[illegible] [illegible] crops, more pollen [illegible] from both [illegible] and [illegible] of pollen from the greatest numbers of [illegible] with [illegible] [illegible] [illegible] in fall (90) [illegible] [illegible] common [illegible] of pollen types (?) [illegible] pollen types per site date. [illegible] accounted [illegible] [illegible] Summer [illegible], more Asteraceae pollen [illegible] D. [illegible], [illegible] Station, TX)

[illegible] initiated in [illegible] [illegible] eradication [illegible] to determine the level [illegible] boll weevils (BWT/TX-?) [illegible] and control [illegible] for [illegible] [illegible] fall diapause [illegible] support [illegible] and [illegible] [illegible] plants are [illegible] [illegible] L. C. Adams)

[illegible] resistance monitoring [illegible] of [illegible] bollworm [illegible] [illegible] (TBW) was [illegible] by [illegible] 23 [illegible] [illegible] insects [illegible] [illegible] and [illegible] [illegible] biological [illegible] [illegible] [illegible]

showed that (1) all 3 treatment stages in NuCotn 33 yielded more cotton than an untreated check, but square treatment was best; (2) no treatment of Sure-Grow 125 yielded significantly higher than the untreated check; and (3) NuCotn 33 yielded 67 lb lint per acre more than Sure-Grow 125. Sure-Grow 125 was treated twice for bollworm/budworm; NuCotn 33 was not treated for worms; and both varieties received 8 treatments (2 at pinhead square; 6 in August) for boll weevil and tarnished plant bug. The test will be repeated in 1998. **(D. D. Hardee, L. C. Adams)**

A large field plot study to determine the effects of seed treatments in-furrow and sidedress treatments of aldicarb on early populations and yield was evaluated in DPL 33B and Sure Grow 125 cotton varieties. Populations of thrips and tarnished plant bugs were low in 1997 and were not influenced by any treatment. Plant bug populations were not any higher in 33B than found in Sure Grow 125 cotton. Because of low, early-season insect pressure, no yield response was observed in treatments with aldicarb. In this study, plant bug nymphs and young adults were caged in sleeve cages on plants with aldicarb in-furrow plus sidedress and on cotton without aldicarb. Higher mortality occurred in cotton treated with aldicarb as compared to the untreated check. **(W. P. Scott)**

Fipronil was evaluated in 3-acre replicated plots for control of the tarnished plant bug and boll weevil. Fipronil treatments were applied under Section 18 and were compared to Vydate and Karate. There was not an untreated control. All treatments were very effective in controlling the plant bug and boll weevil. Fipronil treatment had higher yields than both Vydate and Baythroid. **(W. P. Scott, G. L. Snodgrass)**

A large field plot study to compare sampling (sweep net, drop cloth, and visual) and economic thresholds for tarnished plant bug control currently recommended in the Mississippi Insect Control Guide were studied in 33B cotton. For the third consecutive year, extremely low populations of plant bugs occurred in test fields for the entire season. **(W. P. Scott, G. L. Snodgrass)**

An economic and entomological study of growing *B.t.* and non-*B.t.* cotton on 15 farms throughout the Mississippi Delta began in 1997. This is a cooperative study between ARS and the Delta Research and Extension Center. Partial funding from Cotton Incorporated will begin in January 1998. Project will run for three years; 1997 was used to establish cooperators and to purchase needed equipment. **(W. P. Scott, G. L. Snodgrass, F. Cooke)**

Spray table tests were conducted to further evaluate Fipronil and other promising new insecticides on boll weevil mortality. Fipronil applied at 0.05, 0.038, and 0.019 lb AI/ac gave excellent mortality of boll weevils and was equal to that of Vydate at 0.25. **(W. P. Scott, G. L. Snodgrass)**

The effects of thirteen different insecticides were evaluated for boll weevil and tarnished plant bug control in 33B cotton. Plots were 80' x 16 rows. Treatments were compared to an untreated check. The better plant bug suppression was seen in plots sprayed with Regent, Monitor, and Karate. Highest yields were in the Regent treatment. **(W. P. Scott, G. L. Snodgrass)**

In a separate weevil test, Fipronil and a Fiprol-molecule (61096A) was evaluated for weevil mortality using spray table tests. Fipronil gave excellent mortality applied at rates of 0.05, 0.038, and 0.019 lbs AI/ac. Mortality with 61096A applied at rates of 0.1, 0.076, and 0.038 was not as effective as Fipronil. **(W. P. Scott, G. L. Snodgrass)**

Plant bug (susceptible) mortality when exposed to Fipronil (0.05, 0.038), Monitor (0.33), Vydate (0.25), Orthene (0.33), and Sevin (1.0) lbs AI/ac was evaluated using spray table tests. Higher mortality was observed with Fipronil, Monitor, Vydate, and Orthene than with Sevin. **(W. P. Scott, G. L. Snodgrass)**

Plant bug (resistant) mortality exposed to Fipronil (0.05, 0.038), Provado (0.047), Monitor (0.33, (Vydate (0.25), Orthene (0.33), and Sevin (1.0) lbs AI/ac was determined using spray table tests. Fipronil and Monitor provided excellent mortality when compared to other insecticides. **(W. P. Scott, G. L. Snodgrass)**

The fifth year of a research project was continued in which the overall goal is to develop an integrated pest management (IPM) system for control of stink bugs. This IPM system is centered around a trap cropping strategy designed to intercept stink bugs as they migrate from soybean and other host plants into pecan orchards. However, other strategies such as biological control (i.e. parasitoids) and chemical control will be evaluated as part of this IPM program. Furthermore, this strategy is also designed to be integrated with management of these pest species in commonly associated cropping systems, such as soybeans, cotton, and corn. Implementation of this strategy is dependent upon the development of new information regarding: (1) monitoring methods for determining the primary periods of stink bug migration between crops (plant phenology, coupled with GPS and GIS); (2) identification of trap crop plants whose attractiveness is optimally synchronized with stink bug migration; (3) qualitative and quantitative evaluation of stink bug damage threshold to pecan (based upon pecan nut developmental phenology, pecan cultivar, and stink bug population density); and (4) development of methods (biological and chemical) to control stink bugs, either in the source crops (soybeans, cotton and corn) prior to their emigration, as well as in the trap crop and in the pecan orchard. The specific objectives addressed during 1997 were three-fold. First, we evaluated the effectiveness of speckled purple hull pea (SPHP), planted as a trap crop along the margin of a pecan orchard to reduce stink bug feeding damage in pecan (third year of an experiment initiated in 1995). Monitoring of vegetative and fruit phenology in both the soybeans and SPHP was performed. These data indicated that SPHP continued to produce attractive pods until first frost, which coincided with pecan harvest (mid-November). This was similar to our test results in 1995, while production of flowers and attractive pods terminated earlier during 1996. Drop cloth sampling in the soybeans and SPHP enabled detection of peak stink bug migration periods and development of their offspring. Control of stink bugs within the peas was again investigated during 1997, with applications of Sevin and Phaser mixtures applied prior to the potential emigration of the F_1 generation out of the trap crop and into the test orchard. Pre- and post-treatment monitoring of stink bug population levels indicated an acceptable level of stink bug control in the trap crop. Finally, assessment

[illegible] resistance [illegible]

[illegible]

[illegible] and [illegible] resistance [illegible] and S-7 [illegible] approximately [illegible] dispersion [illegible] offspring [illegible] Common [illegible] pests was again [illegible] applied [illegible] the potential [illegible] of the [illegible] and [illegible] defined. [illegible] of [illegible] bug [illegible] the [illegible] family [illegible]

[illegible] Pirimor and [illegible] gave excellent control [illegible] 0.05, 0.038, and 0.01 [illegible] 0.038 was [illegible] (W. P. Scott, G. L. Snodgrass)

[illegible] (susceptible) mortality [illegible] to Pirimor (0.05, 0.038), Monitor [illegible] (Vydate (0.25) [illegible] (1.0) lbs AI/ac was evaluated using [illegible] table tests. Higher mortality was [illegible] with Pirimor, Monitor, Vydate, [illegible] than with Savin. (W. P. Scott [illegible])

[illegible] (resistant) mortality, exceeded in [illegible] (0.05, 0.038), Pirimor [illegible] (0.25) Vydate 0.25 [illegible] (1.0), lbs AI/ac was determined [illegible] table tests. Pirimor and [illegible] mortality [illegible] insecticides. (W. P. Scott, [illegible])

[illegible] of a research program [illegible] in which the overall goal is [illegible] management (IPM) [illegible] of plant bugs. The IPM [illegible] around a trap crop [illegible] intercept adult bugs in [illegible] soybean and other [illegible] orchards. However, other [illegible] as biological control [illegible] chemical control will be [illegible] part of this IPM program. [illegible] strategy is also [illegible] management of [illegible] strains, [illegible] [illegible]

of stink bug feeding damage to pecans is currently in progress, and therefore, trap crop efficacy is uncertain. **[M. T. Smith, B. Horton (pecan grower), M. Hughs (pecan grower), G. L. Snodgrass]**

As an extension of previous experiments, the second objective addressed in 1997 was to evaluate and compare 13 different plants in regard to their phenological synchronicity with stink bug migration, their relative attractancy to stink bugs, as well as their tolerance to environmental conditions which are common throughout the Mississippi Delta and other pecan growing regions (spring and fall rains, summer drought, and late season cold temperatures). This included 4 pea varieties (speckled purple hull pea, zipper cream pea, hill pea, and pinkeye purple hull pea); 4 soybean maturity groups; okra; 2 greens; and kale. Replicated plots of the 13 plants were tested at three separate sites: a dry site (previously in pasture); a wet site (previously in pasture); and an intermediate site (previously in continuous soybean production). Soil evaluation was performed in each replicate at each site. Results from these tests have not yet been analyzed, as field data collections have not been completed. However, it appears that several of the later maturity group soybeans, as well as the okra, were better synchronized with stink bug migrations than were most of the pea varieties. **[M. T. Smith, T. Jenkins (pecan grower), B. Lewis (cotton and soybean farmer), G. L. Snodgrass]**

The third objective addressed in 1997 was to evaluate and determine the mechanism of feeding preference of the two key stink bug species (*Euschistus servus* and *Acrosternum hilare)* in Delta orchards among a representative variety of 15 different pecan cultivars. The cultivars selected were thought to possess different nut characteristics which might influence food preference. Three types of experiments were performed: (1) no-choice cage tests in which individual adults of a single stink bug species were caged onto the nut cluster of a single cultivar at different stages of nut development under field conditions; (2) no-choice cage tests in which individual adults of a single stink bug species were caged onto the nut cluster of a single cultivar, but under controlled laboratory conditions; and (3) choice cage tests in which individual adults of a single stink bug species were caged onto the nut cluster of all 15 cultivars under controlled laboratory conditions. Evaluation of nut damage, as well as the nut characteristics (shuck thickness, shell thickness, shell hardness, and kernel development) are still in progress, as the nuts have only recently been harvested. However, it appears that there is in fact a differential feeding preference among the pecan cultivar, as well as among the two stink bug species and nut developmental stages. It should be noted that all stink bug sampling data clearly indicate that population levels during 1997 were two to three times higher than they have been since 1992. This was particularly true in the soybeans and speckled purple hull pea trap crop plots. Furthermore, an increase in population levels (specifically the southern green stink bug) were also noted in cotton, particularly in the southern area of Mississippi. **[M. T. Smith, T. Jenkins (pecan grower), G. L. Snodgrass, L. Smith]**

Research was focused on the development of biological control for the management of the *Bemisia* complex of whiteflies infesting key agronomic crops in the United States (i.e. cotton, vegetables, ornamentals, etc.). Studies have concentrated on the evaluation of the

factors affecting parasitoid efficacy, specifically temperature and host plant. Initial studies (1994-1995) provided evidence for two climatic strains of *Encarsia formosa*, the most widely utilized and commercially available parasitoid of whiteflies throughout the world. These studies clearly indicated the importance of searching for parasitoids which originate from areas with climates similar to those in the targeted areas for release or introduction. **(M. T. Smith, R. Hennessey)**

Subsequent studies (1995-1997) evaluated the effect of host plant on parasitoid efficacy. These studies included four strains of *E. formosa* (Greece, Egypt, Commercial, Beltsville), and a diverse group of economically important host plants. Both biological parameters of the parasitoids and percent parasitism were evaluated. Host plant characteristics (leaf area and hair density) were measured as potential factors which may affect searching efficacy of the adult parasitoids, and therefore the various biological parameters. Data analysis is in progress. **[M. T. Smith, M. Ciomperlik (APHIS), J. Neal (ARS), M. Morton (Hydro Gardens)]**

In concert with these parasitoid evaluations, a survey of the whitefly and associated parasitoid species in Mississippi was initiated in 1995, and continued in 1996 and 1997. This study is being conducted through the cooperation of USDA-APHIS and Mississippi State University Agricultural Extension Service. This study will serve as a prerequisite for the development of both preventative and direct control strategies for the silverleaf whitefly, as well as a prerequisite for subsequent field evaluation and release program of parasitoids for control of whitefly pest species in Mississippi. This survey has encompassed the four principle growing regions of Mississippi (Delta, Hills, Coastal Plain and the Black Prairie). In the 1995 survey, 175 samples were collected, 97.7% of which were infested with whiteflies. Whiteflies found among the whitefly-infested samples included *Trialeurodes abutilonea* (29.6%), *Trialeurodes vaporariorum* (10.5%), and *Bemisia* spp. (51.7%), as well as a group of unidentified whitefly species (9.3%). Among the *Bemisia* infested samples, adults collected and transferred to zucchini indicator plants failed to cause the expression of the silverleaf symptom in 19.2% of the samples. Implications of these results are under further investigation. Whiteflies were found infesting cotton, soybeans, vegetables (17 species), and ornamentals (16 species), comprising 18.0%, 14.5%, 29.6%, and 37.8%, respectively, of the infested samples, across 19 counties. Parasitoids were collected from 48.6% of the infested samples, and tentatively identified as (% of parasitized whitefly samples): *Amitus* sp. (0.9%), *Encarsia* sp. (33.9%), including *Encarsia americana, Encarsia cubensis, Encarsia meritoria, Encarsia nigricephala, Encarsia pergandiella, Encarsia quaintancei, Eretmocerus* sp. (47.8%), *Metaphycus* sp. (1.7%), *Signiphora* sp. (4.4%), and unidentified species (13.0%). In the 1996 survey, 284 samples were collected, 95.8% of which were infested with whiteflies. Whitefly species found among the whitefly-infested samples included *T. abutilonea* {46.3%), *T. vaporariorum* (14.0%), *Bemisia* spp.(27.6%), as well as a group of unidentified whitefly species (16.5%). Again, among the *Bemisia*-infested samples, adults collected and transferred to zucchini indicator plants failed to cause the expression of the silverleaf symptom in 15.9% of the samples. Whiteflies were again found infesting cotton, soybean, 6 vegetable species, and 26 ornamental species,

comprising 41.9%, 11.8%, 9.2%, and 37.1%, respectively, of the infested samples, across 26 counties. Parasitoids were collected from 10.4% of the infested samples, and tentatively identified as (% of parasitized whitefly samples): *Amitus* sp. (2.8%), *Encarsia* sp. (33.3%), including *E. americana, E. meritoria, E. nigricephala, E. pergandiella, E. quaintancei, Eretmocerus* sp. (41.7%), *Metaphycus* sp. (2.8%), *Signiphora* sp. (2.8%), and unidentified species (13.9%). In the 1997 survey, 744 samples were collected, 58.1% of which were infested with whiteflies. The lower percentage of samples infested with whitefly is due in large part to the fact that sampling was initiated much earlier in the growing season, particularly in cotton, in an effort to more precisely detect the lower early season whitefly populations. Whitefly species found among the whitefly-infested samples included *T. abutilonea* (14.1%), *T. vaporariorum* (50.5%), and *Bemisia* spp. (39.8%), as well as a group of unidentified whitefly species (3.9%). Again, among the *Bemisia*-infested samples, adults collected and transferred to zucchini indicator plants failed to cause the expression of the silverleaf symptom in 12.3% of the samples. Whiteflies were again found infesting cotton, soybean, 9 vegetable species, and 27 ornamental species, comprising 41.9%, 11.8%, 9.2%, and 37.1%, respectively, of the infested samples, across 38 counties. Whitefly density among the various host plants, as well as parasitoid sampling data are currently being compiled and analyzed. It is important to note that *Bemisia argentifolii* was found infesting cotton in 3 southern counties: George (7 fields) and Jackson (4 fields) counties in Mississippi and Mobile (5 fields) county in Alabama. These 16 fields comprise approximately 674 acres. Infestation levels were high enough to cause premature defoliation on 242 acres (5 fields) of the 674 acres. With the exception of a 29.2 acre field located in George County, MS, defoliation generally ranged from less than 2% to approximately 5%. However, the 29.2 acre field had approximately 65% defoliation, with sooty mold totally covering the remaining foliage. It is apparent that premature defoliation resulting from silverleaf whitefly infestations resulted in yield reductions of 39.2%, 13.9%, and 20.9%. It should also be noted that most heavily damaged fields were planted to NuCotn33 (*B.t.* transgenic). Dr. Greg Evans (whitefly parasitoid taxonomist at the University of Florida, Gainesville) assisted with the identification of parasitoid specimens collected during this project. **[M. T. Smith, M. Allred (APHIS), M. Ciomperlik (APHIS), B. Layton (MSU), R. Snyder (MSU), P. Harris (MSU), S. Nakahara (USDA), G. Evans (DPI/UF)]**

A colony of plant bugs having unusual bright red eyes was reared through 1997 in the laboratory. To determine the frequency of occurrence of this recessive mutation in wild populations in the Delta, all adults and nymphs collected in the resistance survey of the Delta (discussed above) during the fall of 1995 and the spring and fall of 1996 and 1997 were examined for the red-eyed trait. A total of 23,735 adults and 12,936 nymphs were examined, and no red-eyed individuals were found. In a large cage field test red-eyed adults were found to be able to mate and produce offspring in cotton. **(G. L. Snodgrass)**

Compounds with possible activity against the tarnished plant bug are being tested in laboratory bioassays this fall and winter. The compounds are from Mycogen Corporation and are being tested under a secrecy

[illegible] monitored [illegible]

[illegible] examined, and no eclosed individuals were found [illegible] were found as [illegible] producing offspring in [illegible] (C. L. Parencia, [illegible]).

Compounds with possible activity against tarnished plant bug are being tested in laboratory, however, [illegible] compounds are from Mississippi Company [illegible] being tested under a [illegible]

[illegible] of an [illegible] parasites [illegible] ... infested samples and [illegible] tified as [illegible] of parasitoids, which [illegible] *Aphanus* sp. (2.8%), [illegible] sp. including [illegible]

In E. ... *Hypera* [illegible] [illegible] [illegible] unidentified sp. [illegible] survey, 746 samples were collected which were infested with [illegible] countless [illegible] ly is due in large part to [illegible] was infested much earlier in the [illegible] season, particularly in cotton, [illegible] more previously [illegible], the [illegible] early [illegible] populations. [illegible] species [illegible] the weevil-infested samples [illegible] (14.1%) [illegible] (10.5%), and [illegible] sp. [illegible] well as a group of unidentified [illegible] (1.9%). Again, among the [illegible] samples [illegible] [illegible] the occurrence of the [illegible] in 12.1% of the samples. [illegible] found infesting cotton, soybean, [illegible] and 27 other [illegible] species, [illegible] 11.8%, 9.2%, and 17.1%, [illegible] infested samples, [illegible] density among the [illegible], as well as parasitoid [illegible] currently being compiled. [illegible] important to note that

agreement. **(G. L. Snodgrass)**

A survey of the Arkansas, Louisiana, and Mississippi Delta was conducted again in the spring (April-May) and fall (September-October) of 1997 to determine how widespread pyrethroid resistance was in tarnished plant bug populations in the Delta. The study was a repeat of surveys conducted in 1995 and 1996, and used the same collection locations and time periods in all three years. At least 50 adult tarnished plant bugs from each of 71 locations (6 in Louisiana, 17 in Arkansas, and 48 in Mississippi) were tested for pyrethroid resistance in the spring and again in the fall. Adult bugs were exposed in glass vials (2 adults per vial) treated with a discriminating dose of 15 μg of permethrin for a 3-h period after which mortality was determined. Susceptible populations (mortalities >90%) were about the same in number in the spring in all three years (30, 32, and 29 locations in 1995, 1996, and 1997, respectively). In the fall of each year resistance increased, and only 11, 7, and 21 of the test populations were susceptible in the fall of 1995, 1996, and 1997, respectively. These results showed that pyrethroid resistance was widespread in the Delta, and that pyrethroid use during the cotton growing season increased resistance in populations as measured in the fall of each year. The decrease in resistance found each year in the spring was due to resistance being recessive and the production of 3-4 generations of plant bugs on wild hosts out of cotton during September-November and April-May of the following year. **(G. L. Snodgrass, W. P. Scott)**

A large plot field test designed to evaluate treatment thresholds (as recommended by the Mississippi Cooperative Extension Service) for the control of plant bugs in cotton, was conducted on a growers farm near Indianola, MS. Plant bug numbers found in the test during June and July were too low to properly evaluate the test. **(G. L. Snodgrass, W. P. Scott)**

Although virgin female tarnished plant bugs have been used as bait to attract males to traps in several studies, no research has been performed that measures trap capture in traps baited with different numbers of females. During this summer we compared the response of plant bugs to sticky traps baited with 1, 5, or 10 virgin females. Traps baited with 10 females captured significantly higher numbers of plant bugs than check traps or traps baited with 1 or 5 females. Traps baited with five females captured significantly more bugs than check traps, and traps baited with 1 female captured higher mean numbers than the check although the difference was not significant. These results demonstrate that increasing the amount of pheromone (number of females) increases trap capture. This information will be useful if a synthetic female pheromone for use in traps is ever developed. **(G. L. Snodgrass, W. P. Scott)**

An area-wide management program with *Helicoverpa zea* nucleopolyhedrovirus (HzSNPV) has been conducted in the Delta since 1990 to control the first generation of bollworm and tobacco budworm in geranium before movement to cotton can occur in the later generations. A study was conducted with HzSNPV to evaluate a lower virus application rate. A circular study area encompassing approximately 40,500 ha was treated in early May with virus to coincide with the larval emergence of bollworms and tobacco budworms. Adult emergence, moth numbers, and virus persistence were monitored to assess

the impact of the virus. Adult emergence was reduced significantly (82.7%) in naturally-infested enclosure cages treated with the virus. Pheromone trap data suggested that total moth emergence was reduced 47% when compared with moth emergence in untreated areas. Wild geranium treated with the virus retained >50% of the original activity 3 days after virus application. **(D. A. Streett)**

Insect virus formulation is an area of considerable interest because viruses can lose residual virus activity due to ultraviolet inactivation or host plant inactivation. Dr. Michael McGuire's research unit (Plant Polymer Research, NCAUR, USDA/ARS, Peoria, IL) has recently developed adjuvants containing starch or lignin as additives to spray formulations that may increase virus persistence. Our collaborative research with Dr. McGuire evaluated field persistence of AcMNPV on cotton using lignin and starch formulations. Inactivation of AcMNPV on cotton foliage was delayed using lignin formulations that extended virus activity to >40% of the original remaining activity (OAR) at two days post application. **(D. A. Streett)**

Preliminary protocols for moth rearing, diet concentrations, and genetic crosses have been evaluated since June 1997. Based on this work, discriminating doses of *B.t.* toxins will be in place for next season's analyses of field populations of *Heliothis virescens* and *Helicoverpa zea*. Further strategies to improve the percentage of successful single-pair matings will be tested before next year's populations of moths are tested. In addition, the lab was equipped for both moth rearing and genetic analyses. **(D. V. Sumerford)**

2. Extramural

E. I. Dupont de Nemours & Co. has several recombinant baculoviruses undergoing development that infect insect pest species of cotton. These recombinant viruses should provide better protection to cotton and offer another tactic to an integrated pest management (IPM) program. A continual effort in the formulation of these baculoviruses will be required to improve virus effectiveness. Formulations that increase the field persistence of baculoviruses have shown some promise and have received considerable interest over the past thirty years. Our research objective was to assess the effect of several formulations on the efficacy of *Autographa californica* (AcMNPV) against *H. zea/H. virescens* in cotton. A comparison of formulations with and without the additive agent blankophor was included in the study. Data were collected to evaluate percent larval infection and virus persistence. Formulations containing the virus caused significantly higher mortality than the check formulation. The addition of the optical brightener, blankophor to the virus formulations caused a substantial increase in percentage mortality in all formulations although it was not significant. A formulation developed at the SIMRU (Dr. M. R. Bell) had the highest percentage mortality among all virus formulations, but the results were not significantly different. **(D. A. Streett)**

Persistence studies with *Helicoverpa zea* nucleopolyhedrovirus (HzSNPV) were conducted in cooperation with the University of Arkansas. Viral persistence was assessed on the early season alternate host plants, white clover, red clover, and velvetleaf. Plant terminals were removed randomly from plots at 0,1,3, 5, and 7 days post-application. *H. virescens* larvae were individually fed a single plant terminal on a given sampling date and

[illegible] to [illegible] resistant [illegible] the [illegible] [illegible] cotton. [illegible] provide [illegible] months [illegible] [illegible] [illegible] [illegible] [illegible] considered [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] activity [illegible] virus [illegible] [illegible] [illegible]. The addition [illegible] [illegible] [illegible] [illegible] formulations [illegible] [illegible] formulation [illegible] (Dr. M. R. [illegible]) [illegible] [illegible] formulations [illegible] [illegible] [illegible] (D. A. Streett)

P[illegible] with [illegible] [illegible] (AcNPV) were [illegible] in [illegible] with [illegible] [illegible] [illegible] at [illegible] [illegible] [illegible] [illegible] and [illegible]. The [illegible] [illegible] [illegible] from plants [illegible] 1, 3, 5, and 7 days post-application. [illegible] [illegible] were [illegible] a single [illegible] [illegible] [illegible] [illegible]

[illegible] significantly [illegible] in [illegible] [illegible] treated with the [illegible] [illegible] that [illegible] [illegible] AcNPV [illegible] in [illegible]. [illegible] with the [illegible] [illegible] [illegible] activity 8 days after [illegible] (D. A. Streett)

Virus [illegible] formulation [illegible] [illegible] [illegible] virus [illegible] [illegible] virus activity due to [illegible] [illegible] or host plant inactivation. Dr. [illegible] McGuire's research [illegible] NCAUR, USDA-ARS, [illegible] has recently developed [illegible] [illegible] starch or lignin as additives [illegible] formulations that may increase virus [illegible]. Our collaborative research with [illegible] evaluated field [illegible] of [illegible] on cotton using lignin and starch [illegible]. [illegible] [illegible] of AcNPV [illegible] was delayed using lignin [illegible] that extended virus activity [illegible] of the original remaining activity [illegible] two days post application [illegible]

[illegible] for [illegible] rearing [illegible] [illegible] [illegible] have been [illegible] June 1991. Based on the [illegible] doses [illegible] [illegible] [illegible] analyses of [illegible] [illegible] [illegible]. Further [illegible] to [illegible] single [illegible] be tested [illegible] year's [illegible] tested. In addition, [illegible] moth [illegible]

then placed on clean artificial diet and reared for 14 days. Virus inactivation did not occur rapidly, and most of the viral activity was lost between day 3 and 5 post-application. **(D. A. Streett)**

B. *INDICATORS OF PROGRESS:*

1. Publications (Published, In Press, Accepted)

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[illegible] 13-17.

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Hardee, D. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] Arizona [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] resistance [illegible] [illegible] [illegible] [illegible] genes [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] 1997.

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[illegible] OF PROJECTS

[illegible] (Published, In Press, [illegible])

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Hardee, D. D., G. D. Jones, and L. C. Adams. Emergence, movement, and host plants of boll weevils in the Delta of Mississippi. For J. Econ. Entomol. (In Preparation).

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3. **Presentations**:

Hardee, D. D. "Management of boll weevil in conventional and *B.t.* cotton," Delta Council Special Briefing on Cotton Issues, Beltwide Production Conference, New Orleans, LA, January 1997. (Invitation).

Hardee, D. D. "Report on resistance monitoring for *B.t.* cotton", IRAC Meeting, Beltwide Production Conference, New Orleans, LA, January 1997 (Invitation).

Hardee, D. D. "Resistance monitoring in *B.t.* cotton: First year observations", Cotton Insect Research and Control Conference, New Orleans, LA, January 1997 (Invitation).

Hardee, D. D. "Review of current cotton insect research at Stoneville." 24th Meeting of Mississippi Agricultural Consultants Association, Mississippi State, MS, February 1997 (Invitation).

Hardee, D. D. "Prepared statement on Future of *B.t.* cotton." Congressional Briefing Conference, Washington, DC, March 1997 (Invitation).

Hardee, D. D. "*B.t.* cotton: Status of insecticide resistance". Cotton Inc. Crop Management Seminar, Memphis, TN, November 1997 (Invitation).

Hardee, D. D. "Status of cotton aphid resistance in the mid-south." Entomological Society of America National Meeting, Aphid Informal Conference, Nashville, TN, December 1997 (Invitation).

Scott, W. P., G. L. Snodgrass, and D. A. Adams. "Influence of early-season treatments on insect populations and yield in Bollgard (96 BG-1) and Sure Grow 501 cotton varieties." Beltwide Cotton Production Conferences, New Orleans, LA, January 1997.

Scott, W. P. "Insecticide resistance in tarnished plant bugs." Rhone Poulenc Cotton Seminar, Memphis, TN, February 1997.

Scott, W. P. "Efficacy of Fipronil on boll weevil." Boll Weevil SERA-IEG Meeting, Monroe, LA, March 1997.

Scott, W. P. "Plant bug and boll weevil control with Fipronil." Rhone Poulenc World Wide Cotton Symposium, Baton Rouge, AL, June 1997.

Scott, W. P. "Selective IPM-compatible insect control chemistry." Florida Entomological Society, Daytona Beach, FL, August 1997.

Scott, W. P. "Results of studies involving *B.t.* cotton." Monsanto Cotton Seminar, Memphis, TN, November 1997.

Smith, M. T., M. Allred, D. Fieselman, and M. Ciomperlik. "Faunistic survey and identification of the whitefly and associated parasitoid species in Mississippi." USDA-ARS Third Annual Review of the Silverleaf Whitefly National Research and Action Plan Meeting, San Diego, CA, January 1997.

Smith, M. T. "Trap cropping system for control of Hemipteran pests in pecan." 90th Southeastern Pecan Growers Assoc. Convention, Savannah, GA, February 1997.

Smith, M. T. "Whitefly and associated parasitoid species in Mississippi:

[illegible] "Defoliants [illegible]
[illegible] in Mississippi [illegible]
[illegible]
[illegible]

[illegible]

[illegible]

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[illegible]

[illegible] Mississippi [illegible]
[illegible]

[illegible] J. [illegible] [illegible], M. [illegible] [illegible] [illegible] identification of [illegible] presented [illegible] Montana State University [illegible] [illegible], Sa [illegible], CA [illegible]

Smith, M. L. "[illegible] [illegible] in [illegible] [illegible]" [illegible] Southampton [illegible] Growers [illegible] [illegible], Sa[illegible] [illegible] 1997.

[illegible] "[illegible]" and [illegible]
[illegible]

D. D. "Management of [illegible] in
[illegible] and [illegible] cotton," [illegible] Cotton
[illegible] Briefing, in Cotton [illegible] Beltwide
[illegible] Conference, New Orleans, LA
[illegible] (Invitation).

D. D. "[illegible] to enhance
[illegible] for [illegible] cotton" [illegible],
[illegible] Production Conference, [illegible]
[illegible] January 1997 (Invitation).

[illegible] D. D. "Resistance management [illegible]
[illegible] year observations" [illegible]
[illegible] and Control Conference, New
[illegible] A, January 1997 (Invitation).

[illegible] D. D. "Review of cotton [illegible]
[illegible] at Stoneville," [illegible]
[illegible] Agricultural Consultants
[illegible] Mississippi State, MS, February
[illegible] (Invitation).

[illegible] D. D. "[illegible] management [illegible]
[illegible] cotton" Congressional Briefing,
[illegible], Washington, DC, March 1997.

"[illegible] cotton: [illegible] of
[illegible] Cotton [illegible] Crop
[illegible], Memphis [illegible] 1997.

Identification, sampling and management." MSU Advanced Cotton Pest Management Workshop: Consultants, Extension, Growers, and Industry, Mississippi State, MS, March 1997. (Invitational).

Smith, M. T. "Low input sustainable pecan production: Emphasis on development of a trap cropping system for control of stink bugs in pecan." Mississippi/Louisiana Pecan Growers Assoc. Meeting, Natchez, MS, June 1997.

Smith, M. T. "Biological control of *Bemisia tabaci* (Gennadius) and *Bemisia argentifolii* Bellows and Perring: An overview of efforts in the United States." Sustainable Agriculture Symposium, Islamabad, Pakistan, August 1997 (invited, but unable to participate due to work load).

Snodgrass, G. L., and W. P. Scott. "Seasonal changes in pyrethroid resistance in tarnished plant bug populations over a two year period in the Mississippi Delta." Southeastern Branch Meeting ESA, Asheville, NC, March 1997.

Snodgrass, G. L., W. P. Scott. "Attraction of male tarnished plant bugs to sticky traps baited with different numbers of virgin females." 44th Annual Mississippi Insect Control Conference, Mississippi State, MS, November 1997.

Streett, D. A., M. R. Bell, and D. D. Hardee. "Update on the area-wide budworm/bollworm management program with virus: Is it a cost effective insurance program?" Beltwide Cotton Prod. Conf., New Orleans, LA, January 1997.

Streett, D. A., and M. R. Bell. "Update on the area-wide budworm/bollworm management program in the Mississippi Delta with baculovirus." 30th Annual Meeting Society for Invertebrate Pathology, Banff, Alberta, Canada, August 1997.

Sumerford, D. V. "Genetic analysis of adaptation to secondary plant compounds by the polyphagous moth *Heliothis virescens*: Evidence of trade-offs in larval performance?" Seminar given to the Department of Entomology, Mississippi State University, Mississippi State, MS, October 1997. (Invitation).

[illegible] Cotton Pest Management [illegible] Conference. [illegible] November [illegible]

Street, D. A. [illegible] "Evaluation of [illegible] management program [illegible] alternative [illegible] programs" [illegible] Cotton [illegible] January [illegible]

Street, D. A. [illegible] Bell. [illegible] program [illegible] Invertebrate Pesticides [illegible] 1997

Summerford, D. V. [illegible] Use [illegible] Evidence [illegible] Seminar [illegible] the Department of Entomology, Mississippi State University, Mississippi State, MS, [illegible] (Invitation)

[illegible] sampling and management [illegible] Cotton Pest Management [illegible] Conference [illegible] Mississippi [illegible] MS, March [illegible] (Invitational).

[illegible] "Low input [illegible] program: [illegible] Emphasis on development of [illegible] system [illegible] control of [illegible] Mississippi [illegible] Natchez, MS, [illegible]

[illegible] "Biological control of Bemisia (Gennadius) and Bemisia argentifolii [illegible] Perring: An overview [illegible] efforts [illegible] States." Sustainable Agriculture [illegible] Islamabad, Pakistan, August [illegible] is partially due to [illegible]

[illegible] G. L. and W. P. Scott. "Seasonal [illegible] resistance in [illegible] populations [illegible] two year [illegible] Mississippi Delta." Southeastern [illegible] ESA, Asheville, NC, March [illegible]

IV. PLANNED RESEARCH CALENDAR YEAR 1998:

A. *NARRATIVE:*

1. <u>In-House</u>

The Stoneville Insect Rearing Research Support Group will continue to maintain seven insect species in 1998. These include: tobacco budworm, bollworm, soybean looper, beet armyworm, velvetbean caterpillar, *Cardiochiles nigriceps*, and *Cotesia kazak*. Assistance will be given to individual scientists in maintaining insects needed for their research. Artificial diet will be supplied in 30 ml plastic cups and 3.8 liter multicellular trays. Efforts will continue to develop lidding for disposal multicellular larval rearing tray (consider the unit tray with cellular covering). The training in insect rearing techniques and the transfer of technology provided to industry will continue. As always, efforts will continue to produce high quality insects at the most economical price possible. The research of approximately 150 scientists within USDA--ARS, private industry, and state universities will be supported by the work of this unit. **(R. L. Ford)**

The insect distribution program with the Cotton Foundation will continue in 1998. This program is expected to be utilized heavily by researchers throughout the United States. Funds provided by this program will be used to defray insect rearing expenses of SIMRU. The egg, pupal, and larval stages of tobacco budworm, bollworm, soybean looper, beet armyworm, and velvetbean caterpillar will be available. **(R. L. Ford)**

Greenhouse and laboratory studies on effect of aldicarb on cotton aphid resistance to insecticides will be expanded to verify previous conclusions. **(D. D. Hardee, L. C. Adams)**

Any new boll weevil attract-and-kill devices supplied by commercial companies will be evaluated to determine their effectiveness in comparison with commercially available devices and traps. **(D. D. Hardee, L. C. Adams)**

A 3rd year study of influence of cotton aphids on ultimate yields of cotton by spraying cotton twice beginning prior to squaring, at first 1/3-grown square, and at first bloom will be repeated using transgenic and nectariless varieties of cotton. **(D. D. Hardee, L. C. Adams)**

Monitoring of resistance to *B.t.* products and transgenic cotton to cotton bollworms and tobacco budworms will be continued and will include colonies of these insects collected in *B.t.* cotton, non-*B.t.* cotton, and corn from as many areas as possible across the Cotton Belt. This will include applications of MVP II insecticide to cotton in a spray chamber, as well as MVP II, Cry IA© protein (from *B.t.* cotton) and Cry IA(b) protein (from *B.t.* corn) incorporated into diet. The objective will be to determine susceptibility levels for possible detection of beginning tolerance or resistance in the field to these products. **(D. D. Hardee, L. C. Adams)**

IV. PLANNED RESEARCH [illegible]

[illegible]

[illegible] D. [illegible]

L. C. Adams

M[illegible] [illegible] transgenic cotton [illegible] bollworm, [illegible] tobacco budworm will [illegible] include colonies of these insects collected [illegible] Bt cotton, non-Bt cotton [illegible] many areas as possible [illegible] This will include [illegible] of [illegible] in cotton [illegible] chambers, [illegible] well [illegible] MVP II, Cry 1Ac protein [illegible] cotton) and Cry 1Ab) protein [illegible] incorporated into diet. The objective will be to determine susceptibility levels for possible [illegible] of beginning [illegible] of resistance [illegible] field to [illegible] D. D. Hardee, [illegible]

Stoneville Insect Rearing Research [illegible] Group will continue to [illegible] insect species in 1998. These [illegible] bollworm, [illegible] cabbage [illegible] *Geocoris*, *Nigriceps* and *Cotesia* [illegible] will be given to individual [illegible] sts in maintaining insects [illegible] Artificial diets [illegible] and [illegible] multicellular [illegible] will continue to develop lidding [illegible] multicellular larval rearing tray [illegible] the unit tray with cellular covering). [illegible] insect rearing techniques and [illegible] technology provided to industry. [illegible] As always, efforts will [illegible] high quality insects at the [illegible] possible. The research [illegible] scientists within USDA-[illegible] industry, and state universities [illegible] the work of this unit. [illegible]

[illegible] program will the [illegible] will continue in 1998. [illegible]

Studies will be expanded on the effectiveness of a patentable product made from surface-modified mineral particles against cotton insects, with emphasis on the cotton aphid. **(D. D. Hardee and cooperators)**

A classical biological control project of kudzu will be initiated. Foreign exploration will be conducted to collect potential control agents. These agents will be maintained at the Biological Control and Quarantine Laboratory, where preliminary bionomic studies will be conducted. **(N. Schiff, L. Williams, and others)**

A study will be initiated to compare the advantages and disadvantages of treating *B.t.* cotton for *Heliothis* with egg and larval thresholds. Yields will be taken from large plots. **(W. P. Scott, D. A. Adams)**

Studies will continue to evaluate new insecticides for various industry groups by spray table testing and small field plots. **(W. P. Scott, G. L. Snodgrass, D. A. Adams)**

Studies will continue on 15 to 18 farms that grow *B.t.* and non-*B.t.* cotton varieties. In cooperation with the Delta Research & Extension Center, an entomological and economic evaluation of both plantings will be conducted on each farm. Yields will be taken from large plots; data on gin turnout and quality will be obtained. **(W. P. Scott, F. Cooke, G. L. Snodgrass)**

Ecological investigations on fruit flies and their natural enemies will be conducted. Emphasis will be on studies necessary for the development of effective and practical augmentative release strategies. **(J. Sivinski, E. Harris, L. Williams, and others)**

Investigations to determine the utility of a trap cropping system designed to intercept migrating stink bug species as they move among the agricultural landscape will be continued. More specifically, evaluation of trap crop efficacy will be continued, but in a replicated test in which paired orchards are selected, where the periphery of one orchard within each pair will be planted with a trap crop, and the other orchard within each pair will remain without a trap crop. These tests will incorporate the use of GPS and GIS in order to better identify the agricultural landscape (sources of stink bugs) and to understand stink bug movement. Evaluation of a variety of trap crop plants will also be continued during 1998. Finally, evaluation and determination of the mechanism of feeding preference among the two stink bug species (*Euchistus servus* and *Acrosternum hilare*) in Delta orchards among a representative variety of 15 different pecan cultivars will be continued during 1998. These tests will incorporate the use of GPS and GIS in order to better understand the spatial aspects of stink bug movement and damage distribution as they relate to feeding preference. As time permits, biological control of stink bugs, specifically with egg parasitoids, will be investigated. **(M. T. Smith, L. Smith, G. L. Snodgrass)**

Survey of whitefly and associated parasitoids within Mississippi will intensify in 1998, particularly in *B.t.* transgenic cotton and in the boll weevil eradication areas of the state. In addition, the use of molecular techniques will be incorporated in order to verify the *Bemisia* species identification. Additional investigations of parasitoids of the silverleaf whitefly, *Bemisia argentifolii*, will be continued. These studies will include: (1) genetic evaluation of the 4 *E. formosa* strains

in order to develop potential markers that may be used to differentiate these strains, which in turn could be utilized in monitoring their genetic stability as it relates to parasitoid efficacy (Dr. Keith Hopper, USDA-ARS); (2) evaluation of artificial diets for rearing whitefly parasitoids (Dr. Walker Jones, USDA-ARS); (3) evaluation of interspecific interactions among parasitoid species (S. Naranjo, G. Jackson, M. Hunter); and (4) continued efforts towards the joint research program with Dr. Regina Vilarinho de Oliveira (EMBRAPA, CENARGEN, Brasilia, Brazil), where the primary objective is to explore for and evaluate New World parasitoid species for control of *B. argentifolii*. **(M. T. Smith)**

Investigations will continue of the seasonal successional phenology of key legumes (clover species in particular) which are native to the Mississippi Delta. The objective of this investigation is to develop a season-long succession of cover crops as refugia for natural enemies of pecan aphids. **(M. T. Smith, T. Jenkins)**

Area-wide studies of tarnished plant bugs will be initiated in 1998 to study the possibility of managing these insects over a large area with a combination of herbicide sprays to and mowing of alternate host plants; trap crops and selective insecticide applications; and nectariless (*B.t.* and non-*B.t.*) cottons. **(G. L. Snodgrass, W. P. Scott, D. D. Hardee)**

Movement studies designed to determine how far adult plant bugs can move will be conducted by release and recapture of marked adults or their offspring. Mated adults from a laboratory colony with the mutant red-eyed trait will be used in the study. **(G. L. Snodgrass)**

Laboratory bioassays testing compounds provided by Mycogen for their activity against the tarnished plant bug will be continued through the winter and spring. **(G. L. Snodgrass)**

Insecticide resistance in the tarnished plant bug will continue to be investigated. Research will focus on collecting bugs from different parts of the Delta and testing them for resistance to the organophosphate acephate (Orthene). This insecticide has been reported to be becoming less effective over the past two years. **(G. L. Snodgrass, W. P. Scott)**

Tarnished plant bug nymphs will be collected in non-agricultural areas (areas where insecticides are not used on row crops) of Mississippi beginning in the spring. Part of the nymphs will be dissected to determine rates of parasitism (mainly braconid wasps), the remaining nymphs will be reared to obtain adult parasitoids. Results will be compared to previous work done in the Mississippi Delta to try and determine the impact of agricultural practices on natural regulation of plant bug populations. **(G. L. Snodgrass, W. P. Scott)**

An area-wide management program with HzSNPV will be conducted during 1998 on 20,000-ac in the Delta to control the first generation of bollworm and tobacco budworm. It is our intention to evaluate the impact of a lower virus application rate with a virus enhancing agent that may still provide adequate suppression of the pest population and allow us to reduce the cost of future area-wide programs. **(D. A. Streett)**

A protocol will be developed to evaluate transgenic cotton in the field. Several

transgenic cotton varieties will be evaluated under conditions of extremely high insect pressure. The temporal and spatial distribution of insect pests on transgenic cotton will be monitored during the season. Transgenic gene expression in different plant parts will also be monitored during the season and under different environmental conditions. **(D. A. Streett)**

Genetic variability for tolerance of Cry I A(b) (*B.t.* toxin expressed in transgenic corn) and Cry I A(c) (*B.t.* toxin expressed in transgenic cotton) in field-collected populations of *Helicoverpa zea* will be examined using mated females captured at light traps throughout the Mid-South area. These data will create baseline estimates of heritability of *B.t.* resistance, as well as determine if there is a genetic correlation between the tolerance of Cry I A(b) and Cry I A(c) toxins. **(D. V. Sumerford)**

Genetic variability for tolerance of Cry I A(c) (*B.t.* toxin expressed in transgenic cotton) in field-collected populations of *Heliothis virescens* will be examined by mating males collected from pheromone traps to females from a laboratory strain of *H. virescens* expressing high levels of resistance to Cry I A(c). These data will create baseline estimates of heritability of *B.t.* resistance. **(D. V. Sumerford)**

Studies will be set up to determine if a genetic correlation (positive or negative) is present for the tolerance of *B.t.* toxins and the tolerance of conventional insecticides that will be used in the 80%/20% refuge management strategy of *Helicoverpa zea*. **(D. V. Sumerford)**

Field studies will examine if there is variation among *Helicoverpa zea*/ *Heliothis virescens* families in their abilities to perform on *B.t.* and non-*B.t.* cottons. **(D. V. Sumerford)**

Genomic mapping projects of *Heliothis virescens* and *Helicoverpa zea* will be started using RAPD markers. The genome maps will eventually be used to better understand the inheritance of *B.t.* resistance, as well as identification of parents in questionable genetic crosses. **(D. V. Sumerford)**

Selection for tolerance of Cry I A(b) and Cry IA (c) in different colonies of *Helicoverpa zea* will begin. Eventually, these colonies and the RAPD genome map will be used to map quantitative-trait loci in order to better dissect the genetic mechanism(s) underlying *B.t.* resistance in *Helicoverpa zea*. **(D. V. Sumerford)**

Immunological marking will be used to study early-season dispersal of bollworm/budworm, tarnished plant bug, and their natural enemies from uncultivated hosts to crop hosts. Spatial statistics will be used to characterize the subsequent distributions of these insects in crop hosts. **(L. Williams and others)**

The impact of parasitoids on bollworm/ budworm populations inhabiting uncultivated hosts during the early-season will be studied. Immunological techniques will also be used to determine the relative impact of different predators on bollworm/budworm and tarnished plant bug on uncultivated hosts and crop hosts. **(L. Williams and others)**

Habitat management studies will be initiated toward the conservation of natural enemies of bollworm/budworm and tarnished plant bug. Emphasis will be placed on understanding the factors (e.g., plant hosts providing nutrition or shelter) necessary for the enhancement of

[illegible]

[illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] variability will be [illegible] [illegible] of extremely [illegible] [illegible]. The [illegible] and [illegible] [illegible] of insect pests on [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] also be [illegible] [illegible] different [illegible] conditions [illegible].)

[illegible] tolerance [illegible] [illegible] [illegible] (c) (9.1 [illegible] [illegible] in field-collected populations of [illegible] will be examined [illegible] [illegible] [illegible] the Mid-South area. These data [illegible] but these estimates of the [illegible] [illegible], as well as determination of the [illegible] correlation between the tolerance of [illegible] A(?) and [illegible] Alco [illegible] [illegible] [illegible].

[illegible] variability for tolerance [illegible] [illegible] [illegible] expressed [illegible] [illegible] [illegible] [illegible] populations of [illegible] will be examined by mating [illegible] [illegible] [illegible] laboratory strain of [illegible] [illegible] levels of resistance [illegible] The data will [illegible] basis [illegible] of heritability of [illegible] resistance [illegible].

[illegible]

[illegible] (metabolism) in [illegible] [illegible] [illegible] and the [illegible] of [illegible] that will be used [illegible]

overwintering and spring populations of natural enemies. **(L. Williams and others)**

Studies will be initiated to determine the compatibility of natural enemies, inherited sterility, and microbial agents for control of bollworm/budworm in uncultivated hosts. **(L. Williams, J. E. Carpenter, and others)**

Wolbachia are bacteria that infect several families of parasitic Hymenoptera. These bacteria can cause parthenogenosis, mating incompatibility, male-lethal infections, and influence female-biasing and male-biasing sex ratio distortion. Thus, *Wolbachia* can have profound impact on mass rearing programs and the success of subsequent augmentative releases. Studies will be conducted to determine baseline levels of infection in 1) parasitoids of bollworm/budworm in the Delta, and 2) parasitoids currently being reared by the Stoneville Insect Rearing Group. Based on the results of these surveys, future investigations will be planned. **(L. Williams and others)**

2. <u>Extramural</u>

Collaborative research will continue with E. I. Dupont de Nemours & Co. to evaluate the field activity and field stability of several genetically-modified viruses in cotton. The impact of these viruses on non-target insect populations will be evaluated. **(D. A. Streett, G. L. Snodgrass)**